



Patent
Attorney's Docket No. 026125-076

UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of)

Erland CASSEL et al.)

Application No.: 09/887,144)

Filed: June 22, 2001)

For: Antenna For a Portable)
Communication Apparatus, and a)
Portable Communication Apparatus)
Comprising Such an Antenna)

Group Art Unit: 2821

Examiner: Unassigned

#5

CLAIM FOR CONVENTION PRIORITY

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed:

Swedish Patent Application No. 0002375-4

Filed: June 22, 2000

In support of this claim, enclosed is a certified copy of the prior foreign application. The prior foreign application was referred to in the oath or declaration. Acknowledgment of receipt of the certified copy is requested.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

Date: October 16, 2001

By:

Stephen J. Tytlan
Registration No. 45,846

P.O. Box 1404
Alexandria, Virginia 22313-1404
(919) 941-9240

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Commissioner of Patents and Trademarks, Washington, D.C. 20231, on 10/16/01
Date

S. Sneed
(Typed or printed name of person signing the certificate)

S. Sneed
(Signature of person signing the certificate)

10/16/01
(Date of Signature)

PRV

PATENT- OCH REGISTRERINGSVERKET

Patentavdelningen



Intyg Certificate

Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.



(71) Sökande Telefonaktiebolaget L M Ericsson (publ), Stockholm
Applicant (s) SE

(21) Patentansökningsnummer 0002375-4
Patent application number

(86) Ingivningsdatum 2000-06-22
Date of filing

Stockholm, 2001-06-29

För Patent- och registreringsverket
For the Patent- and Registration Office


Christina Vängborg

Avgift
Fee 170:-

**PATENT- OCH
REGISTRERINGSVERKET**
SWEDEN

Postadress/Adress
Box 5055
S-102 42 STOCKHOLM

Telefon/Phone
+46 8 782 25 00
Vx 08-782 25 00

Telex
17978
PATOREG S

Telefax
+46 8 666 02 86
08-666 02 86

**AN ANTENNA FOR A PORTABLE COMMUNICATION APPARATUS, AND A
PORTABLE COMMUNICATION APPARATUS COMPRISING SUCH AN ANTENNA**

5 **Technical Field**

Generally speaking, the present invention relates to
antennas for portable communication apparatuses, such as
mobile telephones. More specifically, the invention relates
to an antenna of the type comprising a radiator having a
10 first end for connection to radio circuitry in the portable
communication apparatus, and a second end.

Description of the Prior Art

A portable communication apparatus, such as a mobile
15 telephone, a cordless telephone, a portable digital
assistant, a communicator or a paging device, requires some
form of antenna in order to establish and maintain a
wireless radiolink to another unit in a telecommunication
system. A widely used antenna in this field is a stub or
20 helix antenna, comprising a helically wound thin metal wire
or ribbon, which is embedded in a protective molding of
dielectric material, or is alternatively covered by a
dielectric radome. FIG 24 illustrates a schematic mobile
telephone 1 having such a stub or helix antenna 2 mounted
25 on the exterior of a top surface of the apparatus housing
of the mobile telephone.

FIG 1 provides a schematic illustration of a
miniaturized end-fed halfwave helix antenna according to
the prior art. The antenna comprises a helical radiator 10
30 having a first end 11, to which an impedance matching
circuit 13 is connected. The purpose of the impedance
matching circuit 13 is to match the high input impedance
(for instance about 200 ohm) of the end-fed halfwave
helical radiator 10 to the lower impedance (normally 50
35 ohm) of a coaxial connector or coaxial cable, which in turn
is coupled to radio circuitry within the portable communi-

Int. I. Patent- och renövert

2000-06- 2 2

Huvudfoxen Kassan

cation apparatus. The helical radiator 10 has a free second end 12. When fed with an electric signal at appropriate frequency(-ies) from the radio circuitry of the portable communication apparatus through the impedance matching circuit 13, the helical radiator 10 acts as a halfwave dipole antenna, as is schematically illustrated by a current arrow I in FIG 1.

Summary of the Invention

10 It is an object of the present invention to provide an antenna with considerable flexibility in terms of bandwidth. More specifically, an object of the present invention is to provide an antenna, which in different embodiments may operate as a single-band antenna, a multi-
15 band antenna and a super broadband antenna.

Another object of the present invention is to provide an improved antenna gain in relation to previously known antennas.

20 Yet another object of the invention is to eliminate the need for a separate impedance matching circuit.

The above objects have been achieved through an antenna according to the enclosed independent patent claim. More specifically, the objects have been achieved by the provision of a feedback conductor having a first end, which
25 is connected to the second or "free" end of the radiator. The feedback conductor is arranged along the radiator in a direction from the second end of the radiator towards the first end or "feeding" end of the radiator. According to different embodiments, by varying the design of the
30 feedback conductor, the width and location of the frequency range, the input impedance, and current distribution may all be tuned as desired.

Other objects, features and advantages of the present invention will appear from the following detailed

Ink. t. Patent- och reg.verket

2000-06- 2 2

Huvudfaxen Kassan

disclosure of embodiments, from the attached drawings as well as from the subclaims.

Brief Description of the Drawings

5 Preferred and alternative embodiments of the present invention will now be described in more detail, reference being made to the accompanying drawings, in which:

FIG 1 is a schematic illustration of a helix antenna according to the prior art,

10 FIG 2 is a schematic illustration, which will assist in explaining the basic principle of the invention,

FIG 3 illustrates a first embodiment of the invention,

15 FIG 4 illustrates a second embodiment of the invention,

FIG 5 illustrates a third embodiment of the invention,

FIG 6 illustrates a fourth embodiment of the invention,

20 FIG 7 illustrates a fifth embodiment of the invention,

FIG 8 is a standing wave ratio (SWR) diagram for the first embodiment shown in FIG 3,

25 FIG 9 is a diagram of the E plane of the antenna in FIG 3 at 880 MHz,

FIG 10 is a diagram of the H plane of the antenna in FIG 3 at 880 MHz,

FIG 11 is a diagram of the E plane of the antenna in FIG 3 at 960 MHz,

30 FIG 12 is a diagram of the H plane of the antenna in FIG 3 at 960 MHz,

FIG 13 is a standing wave ratio (SWR) diagram for the fourth embodiment shown in FIG 6,

FIG 14 is a H plane diagram for the antenna shown in
35 FIG 6 at 880 MHz,

FIG 15 is an E plane diagram of the antenna shown in FIG 6 at 880 MHz,

FIG 16 is a H plane diagram for the antenna shown in FIG 6 at 2110 MHz,

5 FIG 17 is an E plane diagram of the antenna shown in FIG 6 at 2110 MHz,

FIG 18 is a H plane diagram for the antenna shown in FIG 6 at 2400 MHz,

10 FIG 19 is an E plane diagram of the antenna shown in FIG 6 at 2400 MHz,

FIG 20 illustrates the transmission curve S_{11} (in the central portion of the diagram shown in FIG 20) as well as the standing wave ratio curve (in the lower portion of the diagram) between 0.3 MHz and 3000 MHz for the second
15 embodiment shown in FIG 4,

FIG 21 illustrates a corresponding transmission curve S_{11} and standing wave ratio curve for an antenna like the one shown in FIG 4, where, however, the feedback conductor has been removed,

20 FIG 22 corresponds to FIG 20 but covers a higher frequency range from 3 MHz to 6000 MHz,

FIG 23 corresponds to FIG 21 but covers the higher frequency range of FIG 22, i.e. from 3 MHz to 6000 MHz, and

25 FIG 24 schematically illustrates a portable communication apparatus in the form of a mobile telephone.

Data in the diagrams shown in FIGs 8-19 relate to the input point of the antenna, whereas data in the diagrams shown in FIGs 20-23 relate to the input point of the measurement equipment.

30

Detailed Disclosure of Embodiments

This section will describe a novel feedback antenna, which in different embodiments may be used for a single frequency band, multiple frequency bands or for super
35 broadband applications (covering up to 2 octaves). In its

2000-06-22

5

Huvudlösen Kassan
Huvudfaxen Kassan

different embodiments, the antenna according to the invention may be realized as an end-fed miniaturized quarterwave-resonant radiator or as a halfwave-resonant radiator having its center frequency in a desired lowest frequency band.

First, reference is again made to FIG 1, which illustrates a known antenna design for a miniaturized end-fed halfwave antenna, where a thin metal wire or ribbon is wound in a helical shape so as to form a helical radiator or helix 10. As previously mentioned, the impedance matching circuit 13 is required in order to match the higher input impedance of the end-fed halfwave dipole radiator 10 to the lower impedance of a coaxial contact or a coaxial cable, which connects the radiator 10 to radio circuitry in the portable communication apparatus.

Referring now to FIG 2, there is illustrated a theoretical antenna design, where a thin metal wire or ribbon is formed, in a first portion, as a helical radiator 20 having a first feeding end 21 and a second end 22. In contrast to the known antenna of FIG 1, the helical radiator 20 continues, at its end 22, with a linear piece 23 of the thin metal wire or ribbon. The length of the linear portion 23 equals one halfwave, as is schematically illustrated in FIG 2. As is generally known per se, the conduction current equals 0 at the ends of a metallic halfwave radiator. In a situation like in FIG 2, where the current is allowed to continue along the metal wire or ribbon of the radiator after the zero crossing (at position 22 in FIG 2), the phase of the current will change 180° at the zero point of the current amplitude. In other words, the current changes direction completely in the upper halfwave as compared to the lower halfwave. Furthermore, if also the spatial direction of the current is changed 180° by bending the linear piece 23, so that it extends downwardly as in fig 3, this downwardly bent portion 33 (FIG 3) of the thin

metal wire or strip will exhibit the same current direction as the helical radiator 30. In other words the current paths in the helical radiator 30 and the linear portion 33 will have the same direction, as indicated in FIG 3. Admittedly, according the Lenz' law, counter-currents will be generated between these current paths due to the coupling between them; however, thanks to the miniaturization of one of the halfwave radiators and the substantially different design between the two halfwave radiators, the current segments of the two radiators will essentially be orthogonal in relation to each other, wherein aforesaid coupling will be relatively low.

Since the free end of a radiator is of great importance for the phase and amplitude distribution of the radiator current, one may not simply cut off the part of the linear halfwave radiator 23/33, which a priori will extend below the helical radiator 20/30 past the feeding end 21/31. However, the current distribution of the remaining portion of the linear halfwave radiator 23/33 may substantially be maintained, if the lower portion of the linear radiator 33 is formed as an inductive load in the form of an endcoil 34, as shown in FIG 3. The end coil 34 will load the free end of the linear radiator 33 to an extent, so that the loaded radiator 33 will maintain its halfwave resonance. The loading is increased further by arranging the endcoil 34 around the outside of the lower portion of the helical radiator 30 in a vicinity of the feeding end 31 of the latter.

To summarize the teachings this far, by providing a helical radiator 20/30 with a linear feedback conductor 23/33, which is connected to the second end 22/32 of the helical radiator 20/30 and which extends downwardly along the helical radiator 20/30 and ends at a position near the first end 21/31 of the helical radiator 20/30, it is possible to control both the resonant frequencies of the

antenna and its input impedance. Available factors for tuning these parameters are the detailed design of the helical radiator 30, the detailed design of the linear feedback conductor 33, the detailed design of the endcoil 34 and the exact position of the endcoil 34 with respect to the helical radiator 30. If the endcoil 34 of the feedback conductor 33 is placed at the bottom of the helical radiator 30, as shown in FIG 3, resonance may be obtained at a plurality of frequency bands, which are relatively close to each other. For instance, the center frequency of the lowest frequency band may be at 900 MHz, followed by a next frequency at either 1500 MHz or 1750 MHz.

If the endcoil 34 is instead moved closer to the center of the helical radiator 30, the resonant frequency band of the antenna is compressed and is also shifted to lower frequencies, i.e. the resonant range of the lower frequency band is shifted slightly in frequency, whereas higher frequency bands are shifted slightly more in frequency.

Thus, if the antenna is dimensioned correctly, so that a base frequency band (preferably the lowest frequency band) is correctly located, it is possible to adjust the location of other frequency bands, in which it is desired to use the antenna.

In the design illustrated in FIG 3 the antenna is provided with its end coil load 34 at the lower end of the feedback conductor 33. One reason for this is to provide feedback to the helical radiator 30. Another reason is to shorten the mechanical length of the antenna. Now, it is readily realized that when the feedback conductor 33, including the endcoil 34, has an electrical length, which corresponds to one half of a wavelength at a certain frequency, a zero current will be obtained at the uppermost portion 32 of the antenna, i.e. where the feedback conductor 33 is connected to the helical radiator 30, even if the

helical radiator 30 has another electrical length than one half of a wavelength, for instance a quarterwave length. Consequently, the halfwave-like current distribution, which is indicated along the helical radiator 30 in FIG 3, is only one example of a possible current distribution along the helical radiator 30. By providing the endcoil 34 around the helical radiator 30 as in FIG 3, a feedback is obtained by means of which the input impedance (i.e. current and voltage conditions) of the antenna may be controlled. Thus, if the helical radiator is provided with an electrical length, which corresponds to one half of the wavelength, it is possible, thanks to the feedback in combination with a correct dimensioning of the helical radiator 30, to reduce the input voltage and increase the input current of the end-fed halfwave dipole, thereby obtaining an antenna input impedance, which is matched to a 50 ohm system. Therefore, the impedance matching unit 13 of the previously known antenna shown in FIG 1 may be avoided, thereby obviously providing a save in cost.

Moreover, thanks to the reduced input voltage of the antenna, the feedback principle according to the present invention will also reduce the coupling to the apparatus housing or chassis of the portable communication apparatus. As a consequence, an improved antenna gain is available.

FIGs 8-12 represent graphical illustrations of results from measurements, which have been performed for an antenna according to FIG 3. In the measurements, the length of the antenna was 36 mm, and its maximum width was 7 mm. The diagram of FIG 8 illustrates the standing wave ratio (SWR) curve S_{11} of the antenna and also the transmission curve S_{22} . FIGs 9 and 11 show the E plane diagram of the antenna through the main direction of radiation at the frequencies 880 MHz and 960 MHz, respectively. Correspondingly, FIGs 10 and 12 illustrate the H plane diagram at the same frequencies. The 0° direction is the

normal direction of the rear side of the portable communication apparatus. When comparing these measurements to other measurements performed for commercially available antennas of substantially equal size and of recognized quality, it is observed that the antenna according to the invention will provide an increase in antenna gain of about 1.5-2 dB in for instance the GSM band between 880 and 960 MHz. The reason for this may partly be explained by a reduced coupling to the apparatus housing or chassis of the portable communication apparatus and partly by an improved current distribution along the antenna, which makes better use of the entire aperture of the antenna.

A second embodiment of the invention is illustrated in FIG 4. Reference numeral 40 represents a helical radiator, which corresponds to the helical radiator 30 of FIG 3 and which has a first end 41 to be connected to radio circuitry within the portable communication apparatus. The helical radiator 40 also has a second end 42, which in similarity with FIG 3 continues as a linear feedback conductor 43, which is bent downwardly along with the helical radiator 40 towards the first end 41 thereof.

In contrast to FIG 3, the embodiment of FIG 4 is not provided with an endcoil at the end of the feedback conductor 43. Instead, this end is bent once again, so that the direction of the last portion 44 of the feedback conductor 43 changes direction by 180° relative to the elongated linear portion of the feedback conductor 43. The bent end 44 of the feedback conductor 43 is isolated and is inserted inside a first portion of the helical radiator 40. Alternatively, as indicated in FIG 5, the bent isolated end 54 of the feedback conductor 53 may instead be arranged in parallel with the helical radiator 50 outside the helical radiator 50.

The embodiments of FIGs 4 and 5 provide a distributed feedback load in contrast to the endcoil load 34 of the

embodiment shown in FIG 3. The distributed load allows also a miniaturized antenna to be designed to have considerable broadband properties instead of the discrete multi-band properties of the embodiment shown in FIG 3. If the feed-back conductor 43/53 is deeply inserted into the helical radiator 40, or is displaced along a considerable part of the helical radiator 50, the antenna properties are improved at high frequencies, when the resonant frequency ranges of the antenna are shifted towards lower frequencies. The reason for this is that more resonant frequency ranges are added and compressed towards the lowest fixed operating frequency range, as the feedback conductor 43/53 is displaced deeper into or further along the helical radiator 40/50. Thus, there is an expansion of the frequency range, within which the antenna provides good radiation characteristics and matching to e.g. a 50 ohm system.

To this end, reference is made to 20-23. FIGs 20 illustrates the transmission curve S_{11} as well as the standing wave ratio (SWR) curve between 0.3 MHz and 3000 MHz for an antenna according to FIG 4. FIG 22 is a corresponding diagram but covers a higher frequency range between 3 MHz and 6000 MHz. FIGs 20 and 22 are to be compared to FIGs 21 and 23, which represent an antenna like the one in FIG 4 but without the feedback conductor 43, i.e. with only a helical radiator 40. For FIGs 20 and 22, the feedback conductor 43 has been inserted into the helical radiator 40 along about 88% of the longitudinal extension of the helical radiator 40.

An antenna as in FIG 4, with a lowest frequency band at 880-970 MHz, preferably has the following data:

Antenna length	25.5 mm
Number of turns in the helical radiator	20 mm
Wire diameter	0.75 mm
Outer diameter (helical radiator)	3.5 mm
Maximum width	7.0 mm

Ink. t. Patent- och registreringsverket

2000-04-22

Huvudfaxen Kassin

FIG 6 illustrates a fourth embodiment of the invention. The embodiment of FIG 6 is based on the embodiment shown in FIG 4. In addition, the antenna is provided with a base plate 67, through which the first end 61 of the helical conductor 60 is carried. At opposite edges of the base plate 67, a first satellite radiator 65 and a second satellite radiator 66 are mounted. Reference numerals 60-64 correspond to reference numerals 40-44 of FIG 4. The purpose of the satellite radiators 65, 66 is to provide an antenna with super broadband capabilities, up to approximately 2 octaves. The satellite radiators assist in filling some narrow dips in the operational range of the helical radiator 63 and the feedback conductor 64.

Measurement data obtained for an antenna according to the embodiment shown in FIG 6, when mounted to a mobile telephone, are disclosed in FIGs 13-19. FIG 13 illustrates the SWR curve S_{11} (at the lower portion of the diagram) as well as the transmission curve S_{21} (at the upper portion of the diagram). FIGs 14, 16 and 18 illustrate the H plane diagram of the antenna through the main direction of radiation at the frequencies of 880 MHz, 2110 MHz and 2400 MHz, respectively, whereas FIGs 15, 17 and 19 illustrate corresponding E plane diagrams. In the drawings, 0° is a normal direction from the rear side of the mobile telephone. The table below gives a comparison between the maximum radiation obtained at the three frequencies mentioned above for an antenna according to the invention and corresponding values for an ordinary full-length half-wave dipole antenna without feedback. It is to be observed that the length of an ordinary half-wave dipole antenna is about 166 mm at 880 MHz, whereas the length (height) of the inventive feedback antenna is only about 30 mm.

Ink. t. Patent- och reg.verket

2000-06- 2 2

Huvudfoxen Kassan

Frequency (MHz)	Ordinary full-length half-wave antenna without feedback (dB)	Inventive antenna with feedback (dB)	Difference (dBd) [dBi]
880	-18.5	-20.0	-1,5 [+0.6]
2110	-25.5	-25.0	+0.5 [+2.6]
2400	-27.5	-26.5	+1.0 [+3.1]

Preferably, a super broadband antenna according to FIG 6, having a lowest frequency band at 880-970 MHz, has the following data:

Antenna height:	30.0 mm
Number of turns in helical radiator	23
Wire diameter	0.75 mm
Outer diameter of helical radiator	3.5mm
Maximum width of base plate	14 mm
Maximum depth of base plate	11 mm
Maximum top width	11 mm
Maximum top depth	10 mm

5

An improvement of the embodiment shown in FIG 6 is illustrated in FIG 7. The embodiment of FIG 7 is different from the embodiment of FIG 6 in that a curved structure 78 has been provided along the front edge of the base plate 77 with the purpose of displacing the antenna impedance curve in a Smith diagram to a more central position. Moreover, an additional satellite radiator 79 has been provided at a rear edge of the base plate 77. Reference numerals 70-77 correspond to reference numerals 60-67 of FIG 6.

15

All of the embodiments described above may advantageously be embedded in a dielectric material, as is well

known per se to a man skilled in the art. Alternatively, any of the embodiments above may be provided with a dielectric radome, which encloses the antenna. Radome-enclosed antennas are thoroughly analyzed in "Analysis of
5 radome-enclosed antennas", by Kozakoff and Schrank, having ISBN number 0890067163.

The antenna embodiments described above may be used for a variety of portable communication apparatuses, such as mobile telephones, cordless telephones, portable digital
10 assistants, communicators and paging devices. It should be apparent to a man skilled in the art, that the exact design, dimensioning, choice in material, etc, must be carefully selected and tuned depending on a practical application and use.

15 The invention is applicable also to other types of antennas than those which comprise a helical radiator. For instance, a feedback conductor may be added also to a printed-pattern meander-shaped antenna, or to a patch antenna. Specifically, for a printed-pattern meander-shaped
20 antenna, the phase distribution may be controlled by the addition of a feedback conductor according to the invention. Correspondingly, for a patch antenna, a feedback conductor may provide a broader bandwidth of the patch antenna.

25 Moreover, some embodiments of the invention may be formed as a structure in a multi-layer printed circuit board.

Consequently, even if the invention has been described above with reference to a few embodiments, the
30 invention is equally applicable also to other embodiments not shown herein. The scope of the invention is best defined by the appended independent patent claim.

2000-06-22 \\CORRESP\878\POLITIC\DOC\9\1074009.doc SA

Ink. t. Patent- och register

14

2000-06-22

Huvudfaxen

CLAIMS

1. An antenna (2) for a portable communication
5 apparatus (1), the antenna comprising a radiator (30; 40;
50; 60; 70) having a first end (31; 41; 51; 61; 71) to be
connected to radio circuitry in the portable communication
apparatus, and a second end (32; 42; 52; 62; 72),
characterized by
10 a feedback conductor (33; 43; 53; 63; 73) having a
first end, which is electrically connected to the second
end (32; 42; 52; 62; 72) of the radiator (30; 40; 50; 60;
70), the feedback conductor extending along the radiator in
a first direction from the second end of the radiator
15 towards the first end (31; 41; 51; 61; 71) of the radiator.
2. An antenna according to claim 1, wherein said
radiator is an elongated helical radiator (30; 40; 50; 60;
70).
- 20 3. An antenna according to claim 2, wherein a second
end (34) of the feedback conductor (33) is wound in at
least one turn outside the helical radiator (30) in a
vicinity of the first end (31) of the helical radiator.
- 25 4. An antenna according to claim 1 or 2, wherein the
feedback conductor (43) has an isolated second end (44),
which is bent substantially 180°, wherein at least a
portion of said isolated end (44) of the feedback conductor
30 (43) extends inside at least a portion of the helical
radiator (40) essentially in parallel with the longitudinal
axis of the latter.
5. An antenna according to claim 1 or 2, wherein the
35 feedback conductor (53) has an isolated second end (44),
which is bent substantially 180°, wherein at least a

2000-04-22 \\CONSULT\SYSTEMS\PUBLIC\DOC\PI\1074069.DOC BA

15

Ink. t. Patent- och mätverket

2000-04-22

Huvudfoxen Kassan

portion of the isolated end (54) of the feedback conductor (53) extends outside the helical radiator (50) essentially in parallel with the longitudinal axis of the latter.

- 5 6. An antenna according to claim 4, further comprising a base plate (67; 77) and at least one satellite radiator (65, 66; 75, 76, 79), which is mounted on said base plate (67; 77).
- 10 7. An antenna according to claim 6, wherein two satellite radiators (65, 66) are mounted at opposite edges of the base plate (67) and wherein the helical radiator (60) is positioned between the two satellite radiators (65, 66).
- 15 8. An antenna according to claim 6, wherein three satellite radiators (75, 76, 79) are mounted at different edges of the base plate (77) and wherein the helical radiator (70) is positioned between the three satellite
- 20 radiators (75, 76, 79).
9. An antenna according to any preceding claim, wherein the radiator (30; 40; 50; 60; 70) and the feedback conductor (33; 43; 53; 63; 73) are molded into a dielectric
- 25 material.
10. An antenna according to any of claims 1-8, wherein the radiator (30; 40; 50; 60; 70) and the feedback conductor (33; 43; 53; 63; 73) are enclosed in a dielectric
- 30 radome.
11. An antenna according to claim 1, wherein the radiator comprises a printed-pattern meander-shaped conductor.

35

2000-04-22 \\CORRESP\STG\PUBLIC\DOC\2\1074009.doc 2A

16

Ink. i Patent- nr. 987

2000-04-22

Huvudfax

12. An antenna according to claim 1, wherein the radiator comprises a patch antenna element.

13. A multi-layer printed circuit board,
5 characterized by an antenna according to any of claims claim 1-11.

14. A portable communication apparatus, characterized
10 by an antenna according to any of claims 1-12.

15. A portable communication apparatus according to
claim 14, wherein the antenna is formed as a stub antenna
(2) mounted on a housing (1) of the portable communication
apparatus.

15

16. A portable communication apparatus according to
claim 14 or 15, wherein the apparatus is a mobile telephone
(1).

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
21

ABSTRACT

An antenna for a portable communication apparatus has a radiator (40) with a first end (41) to be connected to radio circuitry in the portable communication apparatus, and a second end (42). The antenna also has a feedback conductor (43) having a first end, which is electrically connected to the second end (42) of the radiator (40). The feedback conductor extends along the radiator in a first direction from the second end of the radiator towards the first end (41) of the radiator.

To be published together with FIG 4.

Ink. t. Patent- och ren. verkst

2000-06-22

Huvudfaxen Kassar

1/ 12

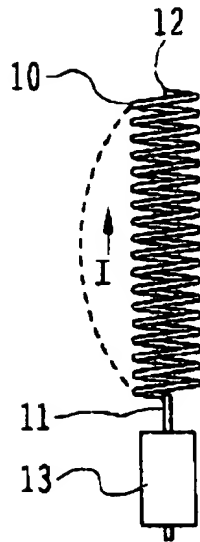


Fig. 1

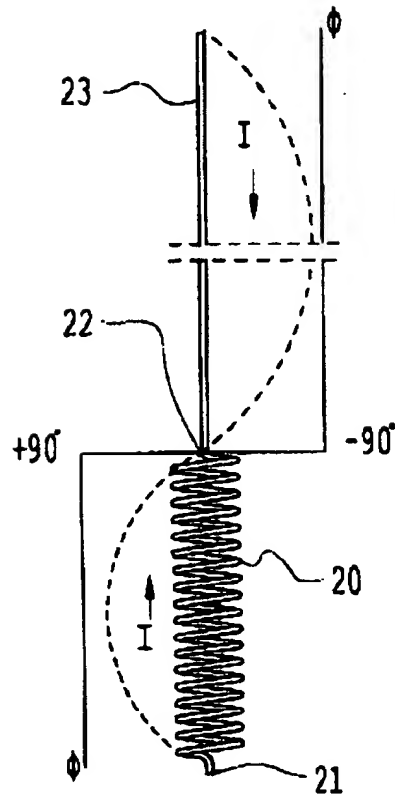


Fig. 2

Ink. t. Patent- och reg.verket

2000-06-22

Huvudfoxen Kassan

2/ 12

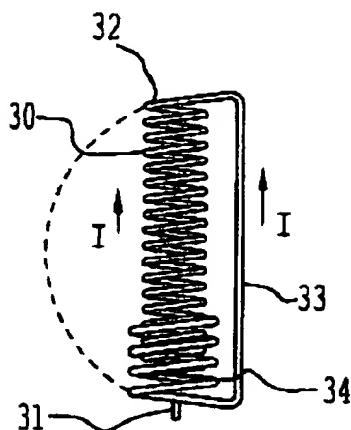


Fig. 3

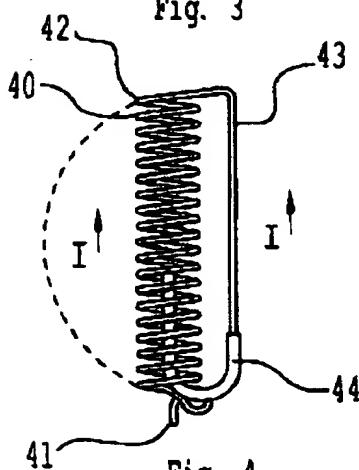


Fig. 4

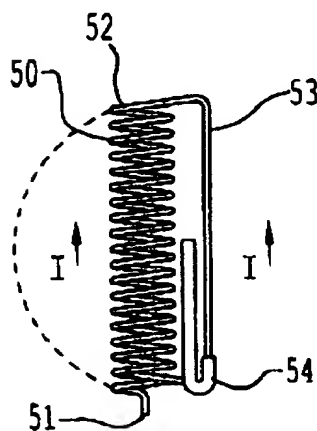


Fig. 5

Sve. t. Patent- och rättsverket

2000-06-22

Huvudfaxen Kassar

3/ 12

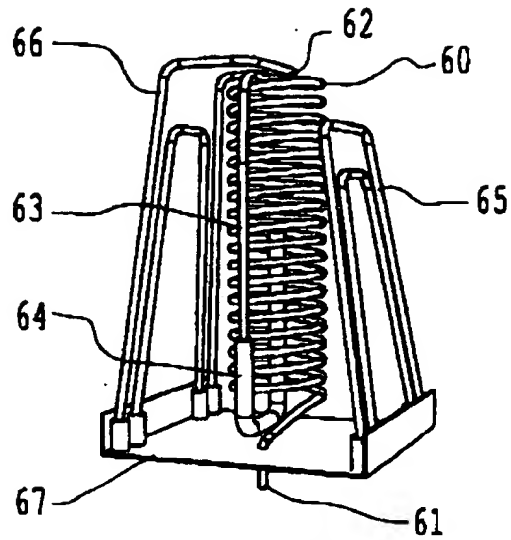


Fig. 6

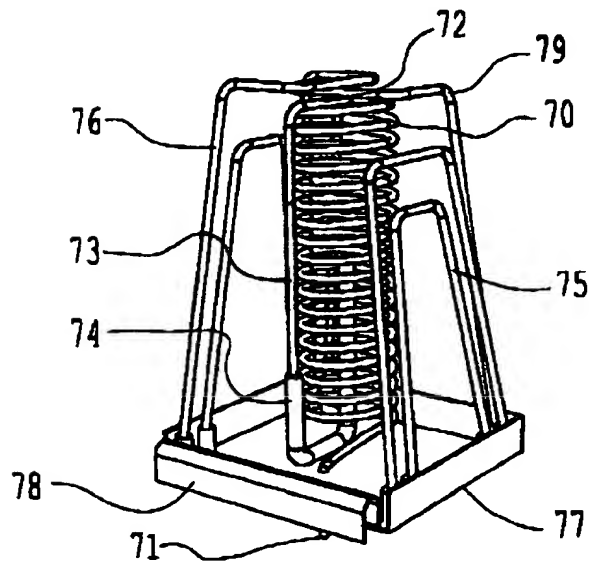


Fig. 7

Ink. t. Patent- och reg.verket

2000-06-22

Huvudfaxen Kassan

4/12

CH1 S_{11} SWR 500 m/ REF 1 3 1.2462
 CH2 S_{12} log MAG 2dB/ REF -30 dB 3: -23.147 dB



Start 600.000 000 MHz Stopp 1 600.000 000 MHz

Fig. 8

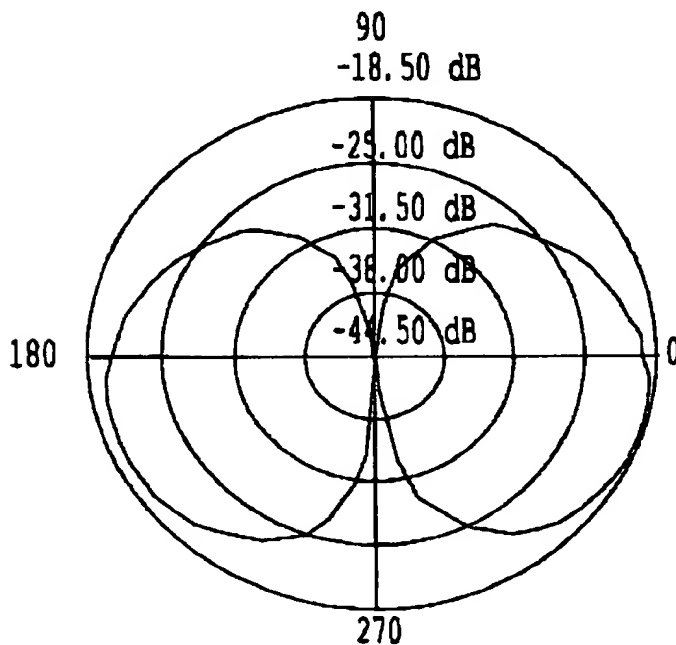


Fig. 9